Process Specification for Ultrasonic Inspection of Wrought Metals

Engineering Directorate

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Prepared by:	***Signature on file***	***6/20/11***
	Ajay M. Koshti, Materials and Processes Branch/ES4	Date
Reviewed by:	***Signature on file***	***6/20/11***
	Norman P. Ruffino, Materials and Processes Branch/ES4 (ESCG)	Date
Reviewed by:	***Signature on file***	***6/17/11***
	David M. Stanley, Materials and Processes Branch/ES4 (ESCG)	Date
Approved by:	***Signature on file***	***6/29/11***
	Bradley S. Files, Chief, Materials and Processes Branch/ES4	Date

REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version	7/26/99
A	Reviewed document per QMS requirements. Updated division name, organization codes, and document numbers.	12/19/02

B	Replaced references to MIL-STD-2154 with AMS-STD-2154. (MIL-STD-2154 was canceled on November 15, 2004.)	1/14/05
C	Added NASA-STD-5009 and NASA-STD-5019	9/25/06
D	Revised 4.0 References, Training and Certification of Personnel	02/16/10
E	Deleted reference to SOP-009.86 from paragraph 4.0. Revised paragraph 9.0 for uniformity across all NDE PRCs.	6/29/11

1.0 SCOPE

This process specification establishes the minimum requirements for ultrasonic inspection of wrought metals and wrought metal components.

2.0 APPLICABILITY

This specification is applicable to in-process, final, and in-service ultrasonic inspections to detect discontinuities in wrought metals and components made from wrought metals with a cross section thickness of 0.250 inch or greater. This specification is not applicable to non-metals, composites, welds, and castings.

3.0 USAGE

This specification shall be invoked by including an inspection note on the applicable engineering drawing or by reference in a Process Specification, Task Performance Sheet, Discrepancy Report/Material Review Record or other appropriate document. The engineering drawing or referencing document shall specify the applicable ultrasonic acceptance class. When there are different acceptance classes for different areas on a component, the drawing shall be zoned with the acceptance class identified for each zone. If the number of components to be inspected and the amount of coverage of each component are not specified, all components shall be examined and shall receive 100 percent ultrasonic coverage.

The standard ultrasonic inspection note for flight hardware and critical ground equipment is given in Figure 1.

PERFORM ULTRASONIC INSPECTION PER JSC PRC-6504, CLASS A.

Figure 1.

3.1 CLASSES

The ultrasonic acceptance class shall be specified in the inspection note or referencing document on the basis of the following:

a. Single discontinuities – Any discontinuity producing an indication greater than the response from a reference flat-bottom hole or equivalent notch at the estimated discontinuity depth of the size given in Table 1 is not acceptable.

b. Multiple discontinuities – Multiple discontinuities producing indications greater than the response from a reference flat-bottom hole or equivalent notch at the estimated discontinuity depth of the size given in Table 1 are not acceptable if the centers of any two of these discontinuities are less than 1 inch apart. Not applicable to Class C.

c. Linear discontinuities – Any discontinuity longer than the length given in Table 1 with an indication greater than the response from a reference flat-bottom hole or equivalent notch at the estimated discontinuity depth of the size given in Table 1 is not acceptable. Not applicable to Class C. For flight hardware, linear discontinuities are not acceptable regardless of length.

d. Loss of back reflection – Loss of back reflection greater than the percent given in Table 1, when compared to a non-defective material in a similar part, is not acceptable when this loss of back reflection is accompanied by an increase in noise signal (at least double the normal background noise signal) between the front and back surface. The loss of back reflection is applicable only to the straight beam tests.

e. Noise – Noise that exceeds the level given in Table 1 is not acceptable, except for reforging stock.

f. Titanium – For Class AAA inspection of titanium, the minimum linear discontinuity length shall be 1/8 inch and the minimum response shall be same as that from 2/64 inch diameter flat bottom hole. For Class AA inspection of titanium, the minimum linear discontinuity length shall be 1/4 inch and the minimum response shall be same as that from 2/64 inch diameter flat bottom hole.

Note: The ultrasonic acceptance class for flight hardware shall be at least Class A.

Table 1. Ultrasonic Acceptance Classes

Class	Single Discontinuity Response (Diameter, inch)	Multiple Discontinuity Response (Diameter, inch)	Linear Discontinuity (Length – Response)	Loss of Back Reflection	Noise Level
AAA	1/64 or 25% of 3/64	10% of 3/64	1/8 inch – 10% of 3/64	50%	10% of 3/64
AA	3/64	2/64	1/2 inch – 2/64	50%	Alarm Level
A	5/64	3/64	1 inch – 3/64	50%	Alarm Level
B	8/64	5/64	1 inch – 5/64	50%	Alarm Level
C	8/64	Not Applicable	Not Applicable	50%	Alarm Level

3.2 INSPECTION SEQUENCE

The stage in the manufacturing process where ultrasonic inspection is performed should be specified on the engineering drawing or in the referencing document.

3.3 DISCONTINUITY ORIENTATION

Unless otherwise specified on the engineering drawing or in the referencing document, ultrasonic inspections shall be performed to detect discontinuities in all orientations. The designer may limit the inspection to the detection of discontinuities with specific orientations by indicating the relevant orientations on the engineering drawing. The designer and fracture analyst should determine the adequacy of inspections that are limited to specific discontinuity orientations.

3.4 SPECIAL NDE OF FRACTURE CRITICAL COMPONENTS

When implementation of fracture control requirements necessitates Special Nondestructive Evaluation (NDE) of a fracture critical component, the requirement for Special NDE shall appear in the inspection note as shown in Figure 2. When Special NDE is required, the specific inspection procedure and inspector shall be qualified in accordance with Section 7.0.

PERFORM ULTRASONIC INSPECTION PER JSC PRC-6504, CLASS A. SPECIAL NDE QUALIFICATION REQUIRED.

Figure 2.

4.0 REFERENCES

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. All documents listed are assumed to be the current revision unless a specific revision is listed. In the case of conflict between this specification and the technical requirements cited in other referenced documents, the requirements of this document take precedence.

ASTM E 2375	*Standard Practice for Ultrasonic Evaluation of Wrought Products*
ASTM B 594	*Standard Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products*

AMS-STD-2154	*Process for Ultrasonic Inspection of, Wrought Metals*
ASTM E 114	*Standard Practice for Ultrasonic Pulse-echo Straight Beam Examination by Contact Method*
ASTM E 214	*Standard Practice for Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves*
ASTM E 213	*Standard Practice for Ultrasonic Examination of Metal Pipes and Tubing*
ASTM E 587	*Standard Practice for Ultrasonic Angle Beam Examination by Contact Method*
ASTM E 127	*Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks*
ASTM E 428	*Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing*
ASTM E 317	*Standard Practice for Evaluating Performance Characteristics of Pulse-echo Examination Instruments and Systems without the Use of Electronic Measurement Instruments*
ASTM E 2192	*Standard Guide for Planer Flaw Height Sizing by Ultrasonics*
ASTM E 1065	*Standard Guide for Evaluating Characteristics of Ultrasonic Search Units*
ASTM E 1316	*Standard Terminology for Nondestructive Examinations*
NASA-STD-5009	Nondestructive Evaluation Requirements for Fracture Critical Metallic Components
NAS 410	*NAS Certification & Qualification of Nondestructive Test Personnel*
NASA-STD-5003	*Fracture Control Requirements for Payloads Using the Space Shuttle*

NASA-STD-5019	*Fracture Control Requirements for Spaceflight Hardware*
SNT-TC-1A	*Personnel Qualification and Certification in Nondestructive Testing*
SSP 30558	*Fracture Control Requirements for Space Station*

The following references were used to develop this process specification:

SOP-007.1	*Preparation and Revision of Process Specifications (PRC's)*
JSC 8500	*Engineering Drawing System Requirements*

5.0 MATERIAL REQUIREMENTS

Couplant and test block materials shall be in accordance with AMS-STD-2154.

6.0 PROCESS REQUIREMENTS

6.1 GENERAL

Ultrasonic inspections shall be performed in accordance with AMS-STD-2154 except as modified by this specification.

6.2 WRITTEN PROCEDURES

A detailed written procedure shall be prepared for each part to be inspected. The procedure shall meet the requirements of this specification and shall ensure the consistency and reproducibility of the inspection at the required sensitivity level. General procedures covering a variety of different parts may be used provided they meet the requirements of this procedure and clearly apply to the parts to be inspected. When general procedures are used, a written part specific technique shall be prepared. At a minimum, the part specific procedure or the general procedure and part specific technique shall cover all of the information required by ASTM-E-2375.

For work performed at JSC facilities, written procedures should consist of Detailed Process Instructions (DPIs) selected for use from the DPI-6504-XX series of work instructions.

6.3 SCAN PLAN

Unless otherwise specified on the engineering drawing or in the referencing document, scan plans shall be designed to detect discontinuities in all orientations. The scan plan shall specify the surfaces from which inspections are to be performed, the ultrasonic beam paths, the scan paths, and the scanning index.

6.4 FRACTURE CRITICAL COMPONENTS

Ultrasonic inspections of fracture critical components shall be performed in accordance with the process requirements in NASA-STD-5009. The requirements NASA-STD-5009 not otherwise covered in this specification are included in the following:

a. Surface finishes shall be 125 RMS or better;

b. Inspections shall be performed with the ultrasonic beam direction as close to perpendicular to the relevant discontinuity orientation as possible;

c. The inspection surfaces shall not be coated; and

d. The component shall not be loaded in compression.

When Special NDE is specified by the engineering drawing or referencing document, the inspection procedure and inspector shall be qualified in accordance with Section 7.0.

7.0 SPECIAL NDE QUALIFICATION

Use of Special NDE in accordance with NASA-STD-5009, NASA-STD-5003, SSP 30558 or NASA-STD-5019 requires formal demonstration of the capability to detect flaws at least as small as the initial crack size for the specific component to a 90/95 detection reliability. Each procedure, procedure application, and operator must demonstrate the required capability. Requests for Special NDE qualification shall be directed to the JSC Materials and Processes Branch (ES4).

8.0 DEVIATIONS AND WAIVERS

Any deviations or waivers regarding the use of this process specification shall be requested in writing. This request shall be directed to the JSC Materials and Processes Branch (ES4) with the appropriate justification and rationale. A written response will be provided upon such a request.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

Personnel performing acceptance inspections of Class I, II, IIIW and GSE hardware shall be qualified and certified, at a minimum, to Level 2 in accordance with NAS 410. Personnel performing acceptance inspections requiring Special NDE shall also be qualified and certified for Special NDE in accordance with NASA-STD-5009.

Personnel performing acceptance inspections of Class III, STE/D, mockup, and facility hardware shall be qualified and certified in accordance with either NAS 410 or SNT-TC-1A. Personnel making accept/reject decisions shall, at a minimum, be certified to Level 2. Level 3 personnel making accept/reject decisions shall have successfully completed a hands-on practical examination equivalent to the examination required for Level 2. Level 1 personnel may perform acceptance inspections under the direct supervision of a Level 2 but shall not make accept/reject decisions.

Formal qualification and certification is not required for personnel performing engineering evaluation inspections.

10.0 DEFINITIONS

90/95	It is an estimate of flaw detection reliability. It can be estimated by the Probability of Detection (POD) analysis of experimental flaw detection data. It implies 90% POD with minimum 95% confidence.
Flaw Detection Capability:	A flaw size with high flaw detection reliability (e.g. 90/95)
Discontinuity	An intentional or unintentional interruption in the physical structure or configuration of a material or component that may be detectable by nondestructive testing; a flaw. Discontinuities are not necessarily rejectable.
Final Inspection	The final inspection performed for the acceptance of the component.
Fracture Critical Component	Classification which assumes that fracture or failure of the component resulting from the occurrence of a crack will result in a catastrophic hazard. Fracture critical components will be identified as such on the engineering drawing.
Indication	Evidence of a discontinuity that requires interpretation to determine its significance.

In-Process	Inspections that occur during manufacturing before a component is in final form.
In-Service	Inspections performed on components that are in use or storage.
Special NDE	A fracture control term denoting nondestructive inspection process with specified personnel, procedures, and equipment with a demonstrated capability to reliably (90/95) detect the specified flaw size that is smaller than those normally detected by the Standard NDE procedures.
Wrought Metals	Wrought metals include forging stock, forgings, rolled billet or plate, extruded or rolled bars, and extruded or rolled shapes.